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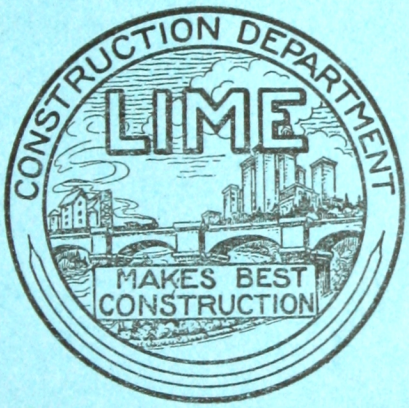
IMPROVING CEMENT PRODUCTS



BULLETIN NO. 302

NATIONAL LIME ASSOCIATION

WASHINGTON, D. C.

ARTIFICIAL STONE and other cement products must possess certain qualities in order to be acceptable for general use in the construction field. Among these properties are:

STRENGTH
WATER-TIGHTNESS
UNIFORMITY

Certain methods of developing these desirable features are discussed in the following pages.

IMPROVING CEMENT PRODUCTS

A DISCUSSION OF THE PROPERTIES OF VARIOUS TYPES OF CEMENT PRODUCTS; AND THE RELATION WHICH HYDRATED LIME BEARS TO THEIR DEVELOPMENT.

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A GROWING INDUSTRY.

The manufacture of concrete products is developing into a profitable business of rather large proportions. This is due partly to the fact that those financially interested recognize that the industry offers tremendous possibilities which can only be destroyed by the shortcomings of the manufacturers themselves. There are innumerable demands for concrete products in almost every locality; the great bulk of the materials entering into the products are found locally; the labor cost is not excessive, and the initial investment in not large.

With the foregoing facts in mind, manufacturers came to realize that one more element was necessary to place the industry on a well-established, profit-paying basis. This element is production of quality;-if the industry is to thrive in a manner commensurate with its possibilities, it must of necessity be built upon a solid foundation of quality and durability.

The object of this booklet is to acquaint all manufacturers with the advantages to be gained by using judicious quantities of hydrated lime in concrete products, working toward the end of maximum strength and durability at a minimum of expense.

IMPORTANT PROPERTIES OF ARTIFICIAL STONE.

Let us first consider what properties the finished product must possess in order to give it all the qualities of a high-class artificial stone.

The first requisite is strength. Any product must have sufficient strength to withstand all reasonable loads that may be imposed. Any excess strength which may be developed over that which is absolutely necessary, will naturally be a factor of safety. Here is an important point—the manufacturer who produces the product that develops the greatest strength, other things being equal, always has an excellent selling argument over his competitor.

Another requisite in some types of products is water-tightness. Its importance depends more particularly upon the purposes for which the products are to be used.

Such matters as uniformity, true and even angles and surfaces, variations in surface texture and finish, are controlled more particularly by workmanship, and will therefore not be treated in this booklet. Maximum strength and water-tightness are both properties which depend partly upon workmanship, but are dependent to a much greater degree upon other factors.

As an example, the strength of concrete products, assuming the workmanship to be first class, depends upon the grading and proportioning of the aggregate, the quantity of cement, and the quantity of water used.

DEVELOPMENT OF STRENGTH.

The strength of the product may be increased or decreased by varying the quantity of cement used. It is customary, in manufacturing cement products, to use a sufficient quantity of cement to produce an article that will pass certain specifications. This is quite logical, but let us consider how strength may be increased without the use of additional cement. It can be done by increasing the efficiency of the cement through proper regulation of the water content.

It is common practice to manufacture certain classes of concrete products by what is known as the semi-dry process; that is, the mixtures used are of a very dry consistency. The reason for this is economy in handling, thus tending to reduce manufacturing costs. As this semi-dry consistency is the standard method in many factories, and particularly those making building blocks, any increase in the free water content is undesirable, so there remains but one method of augmenting the strength, namely, increasing the efficiency of the cement.

There is a well-established theory in concrete practice which, during the past few years, has been proved by several of the foremost scientific concrete investigators in the United States—that the strength of concrete containing a given amount of cement is governed almost entirely by the quantity of water used in mixing. These investigators have conclusively proved that with a given aggregate, maximum strength of concrete containing a given quantity of cement can be produced by using an exact quantity of water. Any increase in free water content over the exact amount necessary to produce maximum strength will cause a decrease in strength. It has also been proved that a decrease in strength results when a quantity of water less than the exact amount is used.

SEMI-DRY PROCESS.

It has already been pointed out that the semi-dry process is commonly used for certain classes of concrete products. In this dry consistency there is an insufficient quantity of water to cause maximum strength to be developed, and for this reason the products do not develop as high strength as is commensurate with the quantity of cement they contain.

In order to develop high strength, it is customary, in many factories, to use the water-spraying or steam-curing methods. The water-spraying method is simple and needs no comments, except that care

should be exercised to see that the flow of water is not so strong as to damage the products during their tender age. Steam-curing produces a combined condition of moisture and warmth, both of which act toward development of high strength. The products are left in the steam room, which is usually held at a temperature around 110° F. for a period of two or three days, when they are removed to the storage yard for seasoning until sold.

When reference is made to increasing the efficiency of the cement in the foregoing, it is not intended to refer to water-spraying or steam-curing but by causing more nearly complete hydration of the cement after the effects of the two methods mentioned have ceased.

WATER CARRYING CAPACITY OF HYDRATED LIME.

A given weight of hydrated lime requires about three times as much water to produce a paste as the same weight of portland cement, so that for each ten pounds of lime used in a mixture for concrete products, there is carried into the mix approximately as much water as would be carried into it by thirty pounds of cement. This water is carried in by purely mechanical action on the part of the lime and the consistency is not changed. The value of this point should not be overlooked—*increasing the moisture content without altering the consistency of the mixture.*

ADVANTAGES OF HYDRATED LIME IN THE SEMI-DRY PROCESS.

Let us now determine what advantages arise from this important function of hydrated lime.

It has already been stated that concrete products are made by the semi-dry process in order to take advantage of economy in handling. In the manufacture of such products, it is customary to handle them almost immediately after being moulded. Concrete of a wet consistency requires considerable time to harden so that it can be safely handled; hence, in order to save time, many manufacturers have adopted the semi-dry process. Heretofore, it has been necessary to use a dry consistency for the manufacture of these products so they could be handled as early as is necessary and at the same time have a minimum of breakage. When hydrated lime is used, it carries a considerably larger volume of water into the mixture, *but does not change the consistency*, so that the products, after moulding, can be handled without loss of time and without any more breakage than when the usual dry mixture process is used.

It has been pointed out that one reason concrete products are not stronger is because the cement frequently works at low efficiency due to an insufficient quantity of moisture being present to cause complete hy-

dration of the cement. When hydrated lime is used in the mixture its high mechanical water-carrying capacity is the direct cause of more nearly complete hydration of the cement.

Cement will hydrate and continue to increase in strength just so long as moisture is available to re-act with the cement. As soon as conditions are such as to make it impossible for moisture to form contact with the cement, hydration ceases, with the consequent result that development of strength also stops.

In the water-spraying and steam-curing methods, the moisture, which is available during the period of treatment, causes a rapid increase in strength. After the products, which do not contain hydrated lime, are put in the storage yard, however, the wind and sun rapidly dry them out and little strength develops from that time. The property that hydrated lime possesses of absorbing and holding water mechanically is, therefore, of material benefit, inasmuch as the hydrated lime holds this water so that it may be drawn upon by the cement in the process of hydration and so make for increased ultimate strength.

Both theoretically and practically it has been fully demonstrated that the addition of hydrated lime to the mixture is of particular benefit in concrete which is subjected to conditions that will cause it to dry out rapidly.

ABOUT WATER-TIGHTNESS

It is very often not only desirable but necessary for concrete products to be rendered water-tight. The various uses to which these products are placed make it almost advisable that all concrete products be made water-tight.

Concrete products are impermeable to water, or water-tight, when they do not permit the passage or flow of water through the pores or voids. If the pores or voids between grains are sufficiently large and connected from surface to surface of the wall, the concrete will be permeable to water.

It is only natural that any material or method the purpose of which is to make concrete water-tight must have for its aim the elimination of structural defects and visible voids and the reduction of the smaller passages by diminishing their size and filling them with finely distributed material of a colloidal nature.

Against limited pressure concrete may be made reasonably water-tight without the use of any material other than portland cement and the aggregates. This, however, is possible only with sufficiently rich mixtures of the proper consistency, selected and carefully graded aggregates, supervision and workmanship of a character that is both extremely rare and expensive. Of course, the addition of any material will not compen-

sate for carelessness, but should assist in producing satisfactory results with ordinary care and less labor.

Many substances have been added to concrete, with a view to making it water-tight, with varying degrees of success.

There are certain technical and economic criteria which determine the degree of usefulness of every structural material and the study of a large number of concrete structures, both in course of erection and during years of service, has shown that a waterproofing material, to satisfy both technical and economic requirements, should possess the following properties:

1. It should in no way injure the concrete, either chemically or physically.

2. It should be preferably of a character chemically similar to that of cement.

3. It should enter the mixture in its most effective form and not rely for its waterproofing quality on chemical reactions that have to take place after it is brought in contact with the ingredients of the concrete.

4. It should be permanent and not subject to decomposition or decay, and, therefore, it should be a mineral rather than an organic compound.

5. The material should be finely divided, bulky, and preferably of a colloidal nature, so as to lubricate the mass during handling and placing and act as a void filler in the hardened concrete.

6. It should readily mix with water and adhere to the other ingredients of the concrete.

7. It should be convenient to handle and easy to proportion and incorporate in the mix.

8. It should be inexpensive so as not to increase the cost of concrete materially.

9. It should be a staple material produced in all parts of the country, rather than a specialty.

10. It should be obtainable wherever portland cement is sold and used.

A moment's reflection on the part of the reader will cause him to determine just how well-hydrated lime fulfills these requirements.

A few years ago the U. S. Bureau of Standards, Washington, D. C., made an extensive investigation into the effectiveness of waterproofing materials. Over forty materials were used, including hydrated lime. The result of the investigation is reported in Technologic Paper No. 3 of the United States Bureau of Standards, and we quote herewith a statement taken from the summary of the report mentioned. This conclusion refers to the use of hydrated lime:-

"This is the most efficient medium employed and resulted in an almost impermeable mortar at the two weeks test. Its value is probably due to its void-filling properties and the same results could be expected from any other finely ground inert material, such as sand, clay, etc."

While from the standpoint of producing a water-tight concrete, the various substances mentioned other than hydrated lime might prove equally effective, their use as a substitute for hydrated lime prove prohibitive from the standpoint of economy when an effort is made to produce sand or clay in as finely divided particles as hydrated lime.

Our recommendations for a 1-5 mix are 8 pounds of hydrated lime per bag of cement; 1-6 mix, 10 pounds hydrated lime; 1-7 mix, 12½ pounds hydrated lime. Hydrated lime can be accurately and conveniently measured. A 6-quart pail, heaping full, holds 8 pounds; an 8-quart pail holds 10 pounds; a 10-quart pail holds 12½ pounds.

EXTRACTS FROM LETTERS
Of Users of Hydrated Lime in Cement Products

From Joseph V. Godfrey, Moorhead, Minn.:-

"I now use 1½ sacks of cement and 20 pounds of hydrated lime to 6 cubic feet of sand and make a block that at thirty days old you have to use a ten-pound sledge to smash. There are many advantages to hydrated lime in blocks.

From Pittsburgh Building Materials Co., Pittsburgh, Kansas:-

"We had occasion a few days ago to examine some cement blocks made about a year ago in which hydrated lime was used in proportion of 1 to 4 and the blocks appear harder, denser, and of a better color than those in which no lime was used. We are now making some fancy columns, mixing with hydrate."

From a prominent manufacturer of cast artificial stone in New England:-

"That its use is an absolute prevention for efflorescence we do not know, but we do know that with its use and the treatment which we give the surface of our product, we do not have efflorescence, *and we are convinced that we could not turn out the high class product that we do without the use of hydrated lime* and we make this statement in selling our product that very few concerns do make, viz., our cut cast artificial stone runs true in grain and color—does not show efflorescence. Our average compression test is 4500 pounds to the square inch and our absorption is less than 4½ per cent.

"If you care at any time to refer any inquiring friends to us with reference to the use of hydrated lime in cut cast stone, we should be more than pleased to give them any information we possess."

PUBLICATIONS
OF THE
NATIONAL LIME ASSOCIATION

Construction Department

No.		
	History, Manufacture and Uses of Hydrated Lime by E. W. Lazell, Ph.D.—(Vellum Bound)...50 cents	98 pages
	Better Plastering and Better Acoustics by Lawrence Hitchcock (Vellum Bound) ...35 cents	36 pages
	Improving Concrete Roads	24 pages
	Field Test of Hydrated Lime in Concrete Roads	8 pages
300	Ideal Brick Mortar	32 pages
	Standard Specifications for Lime Plaster	20 pages
	Auditorium Acoustics	12 pages
301	Watertight Concrete	24 pages
302	Improving Cement Products	8 pages
303	Test Data of Lime in Concrete and Mortar	20 pages

Agricultural Department

100	What is Agricultural Lime?	4 pages
101	Forms & Equivalent Strengths of Liming Materials	4 pages
102	Calculating the Cost of Liming Materials	4 pages
103	Beneficial Effects of Lime on the Soil	4 pages
104	Methods of Applying Lime to the Soil	4 pages
105	Need for Lime by Soils of the United States	4 pages
106	Burnt Lime vs. Limestone for use on Soil	4 pages
107	Does Burnt Lime Destroy Humus?	4 pages

Chemical Department

200	A New Method of Sewage Disposal	16 pages

OTHERS IN PROCESS.

Any of the above bulletins will be sent upon request—free, except as noted.


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